POLITECNICO DI MILANO

PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 39th cycle

THEMATIC Research Field: VIBRATION-BASED STRUCTURAL HEALTH MONITORING: INNOVATION IN DATA ANALYSIS AND VALIDATION IN THE MONITORING OF BRIDGES MANAGED BY AUTOSTRADA PEDEMONTANA LOMBARDA S.P.A.

Monthly net income of PhDscholarship (max 36 months)
€ 1275.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Research in Structural Health Monitoring (SHM) of bridges has seen increasing interests in the last years for several reasons: (a) the continuous exposition to deterioration and aging, mainly caused by environments and increased service loads and (b) the approaching to the end of bridges design lifetime. SHM is generally defined as a multi-disciplinary process involving the repeated or continuous measurement of the response of a structural system through arrays of appropriate sensors, the extraction from measured data of features which are representative of the health condition and the statistical analysis of these features to detect any novelty or abnormal change in the investigated system. In the last few years, the SHM strategy based on vibration monitoring and operational modal analysis (OMA, i.e. the output-only identification of modal parameters) has received increasing attention in the field of Civil Engineering structures and many dynamic monitoring systems have been installed especially in bridges, all over the world. The research group involved in the research has a wide experience in vibration-based SHM of structures and examples of permanently monitored structures currently

	managed include the Milan Cathedral, the *Campanone* bell-tower in Pontremoli, 3 r.c. tied arch bridges (1917) crossing the Adda river at Brivio, the p.c. bridge crossing the Po river at Borgoforte and one steel-concrete composite bridge overpassing the A4 near Venice.
Methods and techniques that will be developed and used to carry out the research	The theoretical basis of OMA-based SHM is that the modal parameters (i.e., natural frequencies, mode shapes and modal damping ratios) depend on the physical properties of structures such as mass, stiffness and energy dissipation mechanisms. Consequently, changes in the physical properties will lead to detectable changes in the modal parameters. On the other hand, especially natural frequencies turn to be also sensitive to factors other than structural changes, such as the environmental and operational variability (EOV). Hence, vibration-based SHM should distinguish the patterns of variation associated to normal EOV from the ones associated to structural changes or damaged conditions. A typical vibration-based SHM strategy should include various subsequent steps: (a) data acquisition and automated modal parameters estimation (MPE); (b) modal tracking (MT) to establish the time evolution of natural frequencies and mode shapes; (c) highlighting the dependence of modal parameters on EOVs and; (d) using different techniques to identify abnormal changes in natural frequencies and mode shapes. The present research is aimed firstly at the application of the above "traditional" procedure to the data collected on various bridges managed by Autostrada Pedemontana Lombarda S.p.A., where the installation of dynamic monitoring systems is ongoing. Subsequently, innovative procedures will be proposed to improve the computational effectiveness of some steps of the traditional approach (such as the automated MPE, in both frequency and time domain, and the identification of abnormal changes). Finally, the traditional approach will be augmented through the development of a parallel procedure, based on Artificial Intelligence and Autoencoder (AE), aimed at the detection and localization of abnormal structural changes from direct numerical analysis of measured data

	in time domain and/or auto-spectral densities in frequency domain. In order to ease the development of the research program, 3-6 months of internship in the offices of Autostrada Pedemontana Lombarda S.p.A. has to be provisionally scheduled.
Educational objectives	During the PhD period, the applicant will become expert in the following fields: experimental dynamics and operational modal analysis, design and management of monitoring systems, vibration-based novelty (damage) detection, scientific software development (Matlab and Phyton), bridge assessment and management.
Job opportunities	•Bridges and infrastructures management •Design and management of (dynamic) monitoring systems •Structural assessment methods •Development of state-of-art software
Composition of the research group	1 Full Professors 1 Associated Professors 0 Assistant Professors 1 PhD Students
Name of the research directors	Prof. Carmelo Gentile

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	637.5 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Budget for the research activity (only for positions supported by scholarship): total amount Euro 5197.60 per student.
In detail:
- 1st year Euro 1732.53
- 2nd year Euro 1732.53
- 3rd year Euro 1732.54

Additional information about the organization and regultions of ABC-PhD programme can be found in the Regulations for the 39th Cycle of ABC-PhD: download is available at link: https://www.dottorato.polimi.it/en/phd-programmes/architecture/architecture-built-environment-and-construction-engineering

Additional information about ABC department and ABC-PhD programme: available at link: https://www.dabc.polimi.it/

Desk availability: The ABC department provides non-permanent desks to be temporarily booked in common PhD rooms.